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PATENT APPLICATION

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

## UTILITY PATENT APPLICATION TRANSMITTAL LETTER

Atty./Agent Docket No.: CS10744Mailing Date: HerewithExpress Mail Label No.: EL541224324US

To: Assistant Commissioner for Patents  
 Box Patent Application  
 Washington, D.C. 20231

Dear Sir:

Transmitted herewith for filing under 37 CFR 1.53 (b) is a Nonprovisional Utility Patent:

☒ New Application; or a ☐ Continuation, ☐ Division, or ☐ Continuation-in-Part (CIP)  
 Application of prior US application No.          /         , filed on         , having US  
 Examiner         , in Group Art Unit         : of

Inventor(s): **Narendra Pulimi, Li Chen and Vimal Natarajan**For (Title): **Antenna Apparatus With Inner Antenna And Grounded Outer Helix Antenna**This transmittal letter has 2 total pages.

Enclosed are:

- ☒ 2 sheets of drawings, along with 10 pages of specification and claims,
- ☒ Oath or Declaration Combined with Power of Attorney (3 pages)
- ☒ Newly Executed (original or copy)
- ☐ Copy from a prior application (if this is a Continuation/Division with no new matter)
- ☐ Statement deleting named inventor(s) in prior application if this is a Continuation/Division (See 37 CFR 1.63(d)(2) and 1.33(b).)
- ☐ Consider as the above Statement, Please delete as inventors for this application the following inventors named in the prior application:
- ☐ A certified copy of a          (non-US) application S/N          /         , having a filing date of         , and foreign priority to this non-US application for the present application is hereby claimed under 35 USC 119.
- ☒ An Assignment Transmittal Letter and Assignment of the invention to MOTOROLA, INC.
- ☒ An Information Disclosure Statement (IDS), with one (1) PTO-1449, and 2 citation copies.
- ☐ Preliminary Amendment
- ☒ Return Receipt Postcard
- ☐ Petition For Extension of Time for parent application of the present Continuation/Division/CIP application

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## Instructions:

\_\_\_\_\_ Incorporation by Reference (for Continuation/Division application) The entire disclosure of the prior application, from which a copy of the oath or declaration is supplied, is considered as being part of the disclosure of the accompanying application and is hereby incorporated by reference therein.

\_\_\_\_\_ Since the present application is based on a prior US application, please amend the specification by adding the following sentence before the first sentence of the specification: "The present application is based on prior US application No. \_\_\_\_\_/\_\_\_\_\_, filed on \_\_\_\_\_, which is hereby incorporated by reference, and priority thereto for common subject matter is hereby claimed."

\_\_\_\_\_ Please cancel filed claims \_\_\_\_\_.

☒ The filing fee is calculated as follows:

## CLAIMS AS FILED, LESS ANY CANCELED BY AMENDMENT

	NUMBER OF CLAIMS	NUMBER EXTRA	RATE	FEE
TOTAL CLAIMS	16-20 =	0	X \$18	= \$0.00
INDEPENDENT CLAIMS	4-3 =	1	X \$78	= \$78.00
MULTIPLE DEPENDENT CLAIMS			\$260	= \$0.00
			BASIC FEE	= \$690.00
			<b>TOTAL FILING FEE</b>	<b>= \$768.00</b>

☒ Please charge Deposit Account No. 13-4768 in the amount of \$ 768.00 for the Total Filing Fee. Two duplicate copies of this sheet are enclosed.

☒ The Commissioner is hereby authorized to charge any additional fees which may be required now or in the future under 37 CFR 1.16 or 37 CFR 1.17, including any present or future time extension fees which may be required, or credit any overpayment to Deposit Account No. 13-4768. Two duplicate copies of this sheet are enclosed.

Date: 6-29-00

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# ANTENNA APPARATUS WITH INNER ANTENNA AND GROUNDED OUTER HELIX ANTENNA

## FIELD OF THE INVENTION

This invention generally relates to antennas. More specifically, this invention  
5 relates to a multi-band, three conductor antenna.

## BACKGROUND OF THE INVENTION

There is a continuing need to improve the performance of cellular telephone  
antennas. For example, the efficiency of the cellular telephone antenna can  
significantly impact the amount of energy needed to send and receive signals.

If an antenna is inefficient, the power amplifier of a cellular telephone has to  
produce a higher power signal to overcome the inefficiency of the antenna. Moreover,  
on the receive side of operation, the sensitivity of the cellular telephone is impacted by  
the efficiency of the antenna.

Furthermore, cellular telephones are increasingly designed to operate via more  
than one frequency band. A first frequency band of operation might be around 800  
MHz, and a second band of operation might be around 2 GHz. Therefore, there is a  
need for more efficient antenna structures that are adaptable to multi-band operation.  
There is a further need for an efficient antenna structure with a bandwidth large  
enough to cover cellular frequency bands of operation.

## Brief Description of the Drawings

FIG. 1 is a representation of an inner helical antenna structure;

FIG. 2 is a representation of a grounded outer helical antenna structure  
surrounding the inner helical antenna structure of FIG. 1 in accordance with a first  
embodiment of the present invention;

FIG. 3 is a representation of a combination monopole and inner helical antenna structure for use with the grounded, outer helical antenna structure shown in FIG. 2 in accordance with a second embodiment of the present invention; and

FIG. 4 shows the grounded helical antenna structure of FIG. 2 combined with a conductive cellular telephone housing in accordance with a third embodiment of the present invention.

#### Detailed Description of Preferred Embodiments

FIG. 1 is a representation of an inner helical antenna structure 8. The inner helical antenna structure 8 includes a coaxial connector 10 having a center conductor 12 and a ground 14. The inner helical antenna structure 8 further includes a resonator, here shown as inner helical antenna 16 having ends 18 and 20. End 18 is coupled to the center conductor 12 of coaxial connector 10. The inner helical antenna 16 is formed to have helical turns wrapped around a dielectric form material 6 along linear axis 11, and the distance between adjacent turns are substantially equal along the entire length of the inner helical antenna 16.

The electrical length of the inner helical antenna 16 is selected to be near  $\lambda/4$ , where  $\lambda$  is the wavelength corresponding to the desired (resonant) center frequency of the inner helical antenna 16. Several design parameters affect the actual physical length selected for the inner helical antenna 16. For example, the diameter of the helical turns will alter the necessary physical length as is known to those skilled in the art. In the illustrated embodiment, the center frequency is designed to be near 800 MHz for the cellular frequency band.

As already mentioned, the antenna structure shown in FIG. 1, as well as the other embodiments of the invention, are for use with a cellular telephone or other portable, wireless system. A conventional cellular telephone includes a transmitter for transmitting signals, a receiver for receiving signals, a synthesizer coupled to the transmitter and receiver for generating carrier frequency signals, and a controller for controlling operation of the cellular telephone.

FIG. 2 is a representation of a grounded outer helical antenna structure 24 surrounding the inner helical antenna 16 of FIG. 1 in accordance with a first

embodiment of the present invention. In all of the drawing figures, like numbers represent like components. A cylindrical dielectric spacer 30 is situated substantially over the entire portion of the inner helical antenna 16. The spacer 30 insulates the inner helical antenna 16 (FIG. 1) from a second resonant element referred to here as a radio frequency (RF) grounded helical antenna 40 (FIG. 2). The grounded helical antenna 40 is coupled to the ground portion 14 of connector 10 (FIG. 1) at end 42. The grounded helical antenna is wound around the inner helical antenna 16 and the spacer 30 so as to surround the inner helical antenna 16.

The grounded helical antenna 40 is formed to have a first section 50 of adjacent helical turns that are spaced farther apart than adjacent helical turns of the inner helical antenna 16. Furthermore, the grounded helical antenna 40 is formed to have an upper capacitive loading section 52 to tune the grounded helical antenna 40 to substantially the resonant frequency of operation of the inner helical antenna 16. The capacitive loading section 52 is located at an end 44 opposite end 42.

Thus, the first section 50 has a distance between adjacent turns of a first predetermined amount, and the second section has a distance between adjacent turns of a second predetermined amount, where the second predetermined amount is less than the first predetermined amount. This antenna configuration yields improved antenna efficiency, during normal cellular telephone use, with sufficient bandwidth to operate over cellular frequency bands. A variable pitch is utilized in the grounded helical antenna 40 to maximize the bandwidth performance while still maintaining the proper resonant frequency of the grounded helical antenna 40. The resonant frequency of operation of the grounded helical antenna 40 is substantially equal to the frequency of operation of the inner helical antenna 16.

The thickness of spacer 30 (FIG. 2) is selected to be sufficiently small such that grounded helical antenna 40 is tightly electrically coupled to inner helical antenna 16. Once again several design parameters exist to tune the performance of the overall antenna structure. For example, decreasing the distance between helical turns in the capacitive loading section 52 increases the bandwidth of the grounded helical antenna but also increases the resonant frequency. Therefore, the first section is tuned to compensate for the increased center frequency. As mentioned previously, the electrical length of the inner helical antenna 16 is selected to be near  $\lambda/4$ , where  $\lambda$  is

the wavelength corresponding to the center (resonant) frequency of the inner helical antenna 16. The optimal electrical length of the grounded helical antenna was experimentally determined to be substantially  $3\lambda/8$ . It will be obvious to those skilled in the art that other electrical lengths for the inner helical antenna 16 and the grounded helical antenna 40 may be chosen for a same center frequency depending upon other design parameters (e.g. diameter of the helical turns of the grounded helical antenna 40, the spacing between helical turns, the thickness of the spacer 30, etc.).

FIG. 3 shows a multi-band antenna structure 60 for use with the grounded, outer helical antenna 40 (FIG. 2) in accordance with a second embodiment of the present invention. To achieve multi-band operation, a conductive wire, here referred to as monopole antenna 62, runs through the center of the inner helical antenna 16 and the dielectric 6 for the entire length of the inner helical antenna 16. The electrical length of the monopole antenna 62 is  $\lambda/4$ , where  $\lambda$  is the wavelength corresponding to the center (resonant) frequency of the personal communications system (PCS) cellular frequency band, which is approximately 1.8 GHz. The multi-band antenna structure of FIG. 3 is then combined with the grounded helical antenna 40 (FIG. 2) to obtain a multi-band antenna with improved efficiency, during normal cellular telephone use, over a given bandwidth as compared to the prior art cellular telephone antenna technology.

FIG. 4 shows the grounded helical antenna 40 combined with a conductive cellular telephone housing 70 in accordance with a third embodiment of the present invention. Rather than just ordinary plastic, the cellular telephone housing 70 is formed of a conductive material as is known in the art. At least one printed circuit board (PCB) 72 is carried by the cellular telephone housing 70, and the PCB 72 has a metalized ground plane represented by ground 74 as is known in the art. The metalized ground plane and the grounded helical antenna 40 are coupled to the cellular telephone housing 70 through conventional means as is known in the art.

The coupling the grounded helical antenna 40 to ground along with the cellular telephone housing 70 is used in conjunction with the first embodiment shown in FIG. 1 or the second embodiment shown in FIG. 2 to provide additional improvement in antenna performance. It has been observed experimentally that the antenna return currents on the RF ground 74 as well as on the conductive cellular housing 70 are

minimal and the return currents are diverted into the outer, grounded helical antenna  
40. This improves the radiated efficiency while still meeting bandwidth requirements.

The previous description of the preferred embodiments are provided to enable  
any person skilled in the art to practice the preferred embodiments. Various  
5 modifications to these embodiments will be readily apparent to those skilled in the art,  
and the generic principles defined herein may be applied to other embodiments  
without the use of the inventive faculty. For example, the illustrated embodiments  
show an inner helix antenna surrounded by a grounded, outer helix antenna. In  
alternate embodiments, an inner antenna can be surrounded by the grounded outer  
10 helix antenna tuned to substantially the same resonant frequency, but the inner  
antenna is an antenna structure different from a conventional helix antenna. Thus,  
those skilled in the art of cellular telephone antenna design will recognize that other  
antenna structures may be used as the inner antenna, depending upon the design  
parameters (e.g. cost, size, antenna directivity, etc.). Still further, the cellular  
15 telephone of FIG. 4 is shown to include two movably attached housing sections. In an  
alternate embodiment, the cellular telephone comprises only one conductive housing  
section. Still further, other means of connecting the antenna structures to a coaxial  
cable or to a PCB may be employed without deviating from the spirit of the present  
invention.

20 We claim:

## CLAIMS

1. A cellular telephone a multi-band antenna apparatus comprising:
  - a multi-band antenna; and
  - a grounded helical antenna surrounding the multi-band antenna.
2. The multi-band antenna apparatus as in claim 1 further comprising:
  - a cellular telephone housing formed of a conductive material; and
  - a printed circuit board (PCB) carried by the cellular telephone housing, the PCB having a metalized ground plane, the metalized ground plane and the grounded helical antenna coupled to the cellular telephone housing.
3. The multi-band antenna apparatus as in claim 2 wherein the multi-band antenna comprises a helical antenna coupled to a monopole antenna.
4. The multi-band antenna apparatus as in claim 3 wherein the grounded helical antenna includes turns around a linear axis, a distance between at least some adjacent turns of the grounded helical antenna varying along the linear axis.
5. The multi-band antenna apparatus as in claim 4 wherein the grounded helical antenna comprises a top section and a lower section along the linear axis, the lower section coupled to the metalized ground plane and the top section located at an end opposite the lower section along the linear axis, a distance between adjacent turns of the top section narrower than a distance between adjacent turns of the lower section.



1 6. A cellular telephone antenna comprising:  
2 an inner antenna; and  
3 a radio frequency (RF) grounded helical antenna surrounding the inner  
4 antenna, the RF grounded helical antenna including,  
5 a first section having a distance between adjacent turns of a first predetermined  
6 amount, and  
7 a second section having a distance between adjacent turns of a second  
8 predetermined amount, the second predetermined amount less than the first  
9 predetermined amount.

1 7. The cellular telephone antenna as in claim 6 wherein a resonant frequency of the  
2 RF grounded helical antenna is substantially equal to a resonant frequency of the inner  
3 antenna.  
4

5 8. The cellular telephone antenna as in claim 6 further comprising:  
6 a cellular telephone housing formed of a conductive material; and  
7 a printed circuit board (PCB) carried by the cellular telephone housing, the  
8 PCB having a metalized ground plane, the metalized ground plane and the RF  
9 grounded helical antenna coupled to the cellular telephone housing.  
10

1 9. The cellular telephone antenna as in claim 6 wherein the inner antenna comprises  
2 an inner helical antenna.  
3

4 10. The cellular telephone antenna as in claim 9 wherein a resonant frequency of the  
5 RF grounded helical antenna is substantially equal to a resonant frequency of the inner  
6 antenna.  
7

8 11. The cellular telephone antenna as in claim 10 further comprising:  
9 a cellular telephone housing formed of a conductive material; and  
10 a printed circuit board (PCB) carried by the cellular telephone housing, the  
11 PCB having a metalized ground plane, the metalized ground plane and the RF  
12 grounded helical antenna electrically coupled to the cellular telephone housing.  
13  
14  
15

1 12. A cellular telephone antenna comprising:  
2 a monopole antenna tuned to a first resonant frequency of operation;  
3 a first helical antenna coupled to the monopole antenna and having turns  
4 surrounding the monopole antenna, the first helical antenna tuned to a second resonant  
5 frequency of operation; and  
6 an electronically grounded second helical antenna surrounding the first helical  
7 antenna, the electronically grounded second helical antenna formed to have an upper  
8 capacitive loading segment to tune the electronically grounded second helical antenna  
9 at substantially the second resonant frequency of operation.

10 13. The cellular telephone antenna as in claim 12 further comprising:  
11 a cellular telephone housing formed of a conductive material; and  
12 a printed circuit board (PCB) carried by the cellular telephone housing, the  
13 PCB having a metalized ground plane, the metalized ground plane and the  
14 electronically grounded second helical antenna coupled to the cellular telephone  
15 housing.  
16

1 14. A cellular telephone comprising:

2 transmitter for transmitting signals;

3 a receiver for receiving signals;

4 a synthesizer coupled to the transmitter and receiver for generating carrier  
5 frequency signals;

6 a controller for controlling operation of the cellular telephone;

7 a first helical antenna coupled to the transmitter and the receiver, the first  
8 helical antenna tuned to a resonant frequency of operation; and

9 a grounded helical antenna surrounding the first helical antenna, the grounded  
10 helical antenna formed to have a first section of adjacent helical turns that are spaced  
11 farther apart than adjacent helical turns of the first helical antenna, the grounded  
12 helical antenna formed to have an upper capacitive loading segment to tune the  
13 grounded helical antenna to substantially the resonant frequency of operation.  
14

15. The cellular telephone as in claim 14 further comprising:

16 a cellular telephone housing formed of a conductive material; and

17 a printed circuit board (PCB) having a metalized ground plane, the metalized  
18 ground plane and the grounded second helical antenna coupled to the cellular  
19 telephone housing.  
20

21 16. The cellular telephone as in claim 15 further comprising a monopole antenna  
22 coupled to the first helical antenna and tuned to a second resonant frequency of  
23 operation.

ANTENNA APPARATUS WITH INNER ANTENNA AND GROUNDED OUTER  
HELIX ANTENNA

## Abstract of the Disclosure

5 A dual-band cellular telephone antenna. A monopole antenna is tuned to a first resonant frequency of operation. A first helical antenna is coupled to the monopole antenna and has turns surrounding the monopole antenna, where the first helical antenna is tuned to a second resonant frequency of operation. A grounded second helical antenna surrounds the first helical antenna and is formed to have an upper capacitive loading segment to tune the grounded second helical antenna at substantially the second resonant frequency of operation. The cellular telephone has a housing formed of a conductive material. A printed circuit board (PCB) has a metalized ground plane, wherein the metalized ground plane and the grounded second helical antenna are coupled to the cellular telephone housing.

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1 / 2

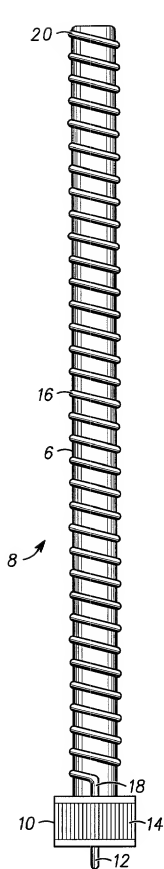


FIG. 1

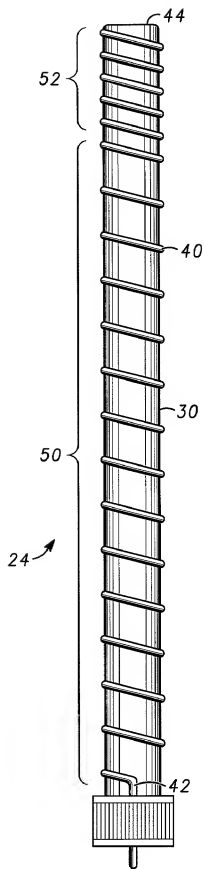


FIG. 2

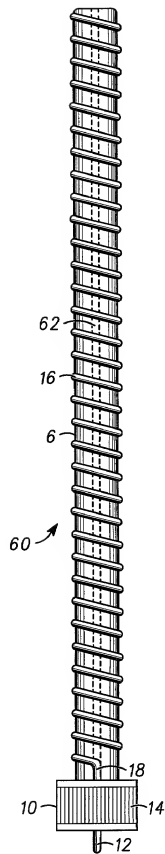
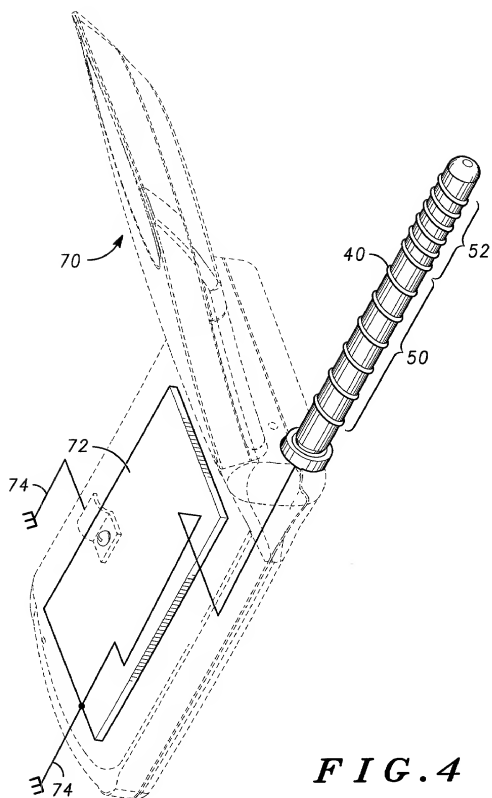


FIG. 3

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**DECLARATION AND POWER OF ATTORNEY  
FOR PATENT APPLICATION**

Docket No. CS10744

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled **ANTENNA APPARATUS WITH INNER ANTENNA AND GROUNDED OUTER HELIX ANTENNA**, the specification of which is attached hereto unless the following box is checked:

☐ was filed on \_\_\_\_\_  
as Application No. \_\_\_\_\_  
and was amended on \_\_\_\_\_.

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information that is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119(a)-(d) of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed.

Prior Foreign Application(s)

Priority Claimed

_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
(Serial No.)	(Country)	(Day/Month/Year Filed)
_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
(Serial No.)	(Country)	(Day/Month/Year Filed)

I hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

_____	_____
(Serial No.)	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose information which is material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application.

_____ (Serial No.)	_____ (Filing Date)	_____ (Status - patented, pending, abandoned)
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_____ (Serial No.)	_____ (Filing Date)	_____ (Status - patented, pending, abandoned)
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I HEREBY APPOINT THE FOLLOWING AS MY ATTORNEY(S) OR AGENT(S) WITH FULL POWER OF SUBSTITUTION TO PROSECUTE THIS APPLICATION AND TRANSACT ALL BUSINESS IN THE PATENT AND TRADEMARK OFFICE CONNECTED THEREWITH:

NAME(S)	REGISTRATION NO.(S)	ASSOCIATE POWER OF ATTORNEY ATTACHED		
Paul J. Bartusiak	42,300			
Rolland R. Hackbart	28,217			
Sylvia Y. Chen	39,633			
		<table border="0"> <tr> <td>_____ Yes</td> <td>_____ <u>X</u> No</td> </tr> </table>	_____ Yes	_____ <u>X</u> No
_____ Yes	_____ <u>X</u> No			

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

FULL NAME OF FIRST INVENTOR Narendra Pulimi	INVENTOR'S SIGNATURE <i>Narendra Pulimi</i>	DATE 6/28/00
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POST OFFICE ADDRESS same as above <i>Li Chen</i>		

FULL NAME OF THIRD INVENTOR Vimal Natarajan	INVENTOR'S SIGNATURE <i>Vimal Natarajan</i>	DATE June 26, 2000
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POST OFFICE ADDRESS same as above		